NORIKS – A WINTER INDEX FOR NORWEGIAN CONDITIONS

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1. Abstract

A winter index is designed to identify conditions where it is necessary to carry out winter road maintenance such as salt/sand spreading or snow clearing. The index will show the actual weather conditions during a period of time (month /season) and will make it possible to adjust payments to the contractors on the basis of the work which has actually been carried out.

In order to ensure the quality of the work, there has been close co-operation with the winter maintenance staff. The method used involves questionnaires directed at the staff, the registration of every single maintenance effort in certain periods, and discussions between developers of the index and staff. As a result of the studies we have drawn up our winter index, NORIKS, based on the formula:

$NORIKS = \Sigma(Temperature\ rise + Temperature\ fall + Precipitation + Drifting\ snow)$,

where the number of cases over a given period of time (for example per week or per month) are added together.

The parameters which make up the equation include the weather conditions which require measures in the form of winter maintenance of roads.

The input data available for index calculations includes data from both The Norwegian Meteorological Institute (DNMI) and from the Norwegian Public Roads Administration's road weather information system. However, the same weather parameters are not being measured at every station. An important target for the project is to develop a method which makes it possible to combine data from road weather stations with data from DNMI and thus produce an index which can be used for a specific geographical area.

2. Background

The use of different winter indices is a recognised method for following up and calculating need and costs in connection with winter maintenance (Gustavsson, 1996). In Norway, large parts of winter maintenance are carried out by private entrepreneurs and sub-contractors. Functional contracts are drawn up which include all maintenance of the national and county highways within a given geographical area. Because of the dependency on weather conditions, a tool is required for winter maintenance which makes it possible to draw up the contracts in the correct way.

Norway is a long and narrow country, with natural variations in weather conditions resulting from its degree of latitude. The influences from surrounding sea areas, mountain ranges dividing east from west and topography with major differences in height over short distances lead to major local variations in the weather. Examples of these variations can be seen in figure 1, which shows the last day of spring with snow on the ground, and figure 2 which shows the distribution of the number of days per year with snowfall.

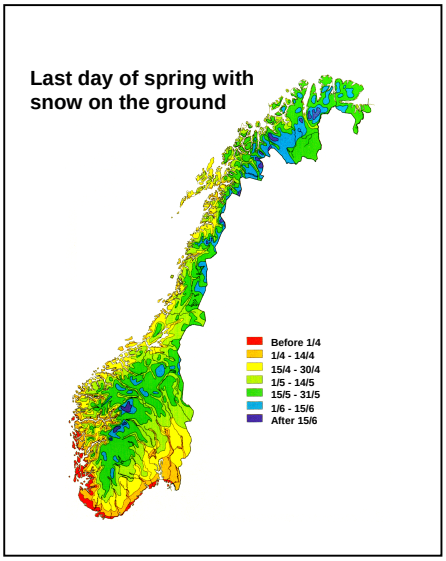

Figure 1: Last Day Of Spring With Snow On The Ground

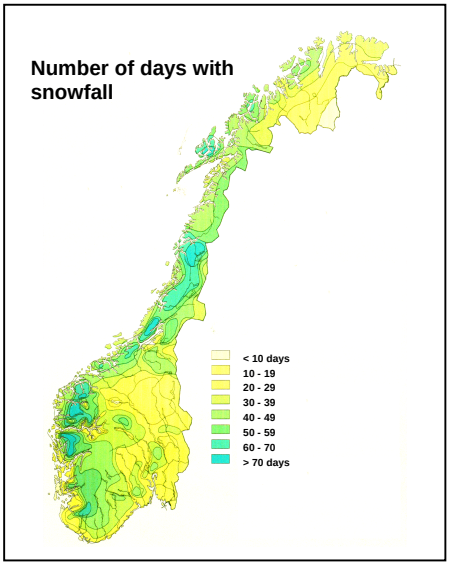

Figure 2: Number Of Days Per Year With Snowfall

The Norwegian Public Roads Administration (NPRA) is responsible for national and county highways in Norway. These are roads which form important links and /or carry heavy traffic. As a result, there are stringent requirements regarding the standard which must be maintained. It is important for the winter index to include a description of the balance between the standard norms which exist and the measures which are actually carried out on the different roads in order to keep them in a state where people and vehicles can travel safely.

In developing the Norwegian NORIKS winter index, special attention has been paid to:

- Meteorological and climatic conditions in Norway
- Standard requirements for winter maintenance in Norway
- Routines for carrying out winter maintenance in Norway
- Available databases

3. Objectives

The purpose of the winter index is that it should become a tool for objectively summing up situations where it has been necessary to implement measures in the form of winter maintenance. For example, using the index, it should be possible to see how many times a given stretch of road should have been snow ploughed, but the main use will concern winter maintenance as a whole and not each type of measure separately.

The major variations in weather and climate mean that winter maintenance is carried out in different ways, depending on the area of the country. An important objective of the winter index work has therefore been to describe local conditions in the best possible way. In order to achieve this objective and to ensure the quality of the results, it has been important to establish close co-operation between the project and those who carry out the work on the roads.

4. Method

As stated, the use of the winter index is connected with functional contracts. At present, these contracts are based on a temporary index /average winter. The winter index will be used to make adjustments according to the actual conditions. Has the winter required more or less input than that which is stated in the contract? Is the deviation so great that compensation may be payable, either by the NPRA to the contractors or vice versa?

Having studied some of the winter indices which exist in Europe and charted the routines which maintenance personnel in two counties in Norway use, it has been shown that the following equation can provide a winter index which describes the Norwegian conditions:

$$NORIKS = \sum(\text{temperature rise} + \text{temperature fall} + \text{precipitation} + \text{drifting snow}) \qquad (i)$$

where the number of cases over a given period of time (for example per week or per month) are added together.

The different elements in the equation represent the following conditions:

Temperature rise

The parameter gives information regarding the number of times there has been an increase in temperature which can be attributed to a change in weather conditions. Such warm air advection can occur in connection with a change from cold, clear winter weather, to more cloudy and humid type of weather. Weather situations of this type can lead to difficult driving conditions and large amounts of frost formation.

Temperature fall

This variable will give information about the number of cases where ice may form when the temperature of the road surface drops below 0°C. Ice formation may result either when liquid on the road freezes or through the formation of frost as a result of the relationship between the drop in temperature and the air humidity.

Precipitation

Precipitation is classified according to type, quantity and intensity. Precipitation, which is included in the winter index, will include snow, snow mixed with rain, or freezing rain. The amount of precipitation must exceed specific limits during a 24-hour period before it can be included in the index. If rain occurs or if the temperature rises to above 0°C after a snowfall, the snow will not be included in the index.

Drifting snow
Drifting snow is a particular problem in exposed areas where the wind can move large amounts of snow. In order for drifting snow to be included in the index, the following conditions must be met:

- Snow has fallen
- The air temperature in the period following the snowfall has not exceeded 0°C and no rain has fallen either.
- Wind speed during the 24 hour period has at one point or another exceeded 7 m/s.

In addition to wind, precipitation and temperature levels are important parameters in dealing with drifting snow.

5. Extent of data

The data, which is used for winter index calculations, comes from stations owned and operated by the NPRA or the Norwegian Meteorological Institute (DNMI).

One of the challenges facing the project are the differences in sensor equipment at the different stations and the location of the stations in different environments and for different purposes. The NPRA has 200 road weather stations and DNMI has in excess of 700 places where various registrations are made. Up until now, an index has been calculated for each type of station in this project, but in spite of the large number of stations, the results show that there is still insufficient information, due to differences in location and sensor equipment.

For the elements *temperature rise* and *temperature fall* in the formula (i) it is important to have information about road surface temperature and the state of the road (dry, damp, snow covered etc) in addition to air temperature. Only the NPRA's road weather stations give this information. With regard to precipitation, there are major differences regarding the type of information which is accessible, and the accuracy of this information (type, amount, intensity). Wind is also a parameter which is only registered in a handful of places.

6. Verification of the index.

In order to ensure that the index represents the work which is actually carried out on the road, the maintenance personnel have registered the activities which they have carried out on special forms during the test periods. Registrations have been made showing the number of times clearing snow, salting, sanding etc. have been carried out and why such measures were carried out at that time (due to precipitation, drifting snow, changes in temperature).

Provisional results show that there is a correlation between the measures which are carried out and the winter index, but some improvements need to be made in the form of weighting parameters in order to optimise the index. Because of the standard norms which already exist, the significance of precipitation is being considered in this project. If large amounts of snow fall over a short period, there is a strong chance that snow clearance must be carried out several times instead of just the once. This must be clear from the index calculations.

By analysing available weather data, the project has concluded that there is a correlation between the amount of incidences of precipitation, and the height above sea level the data was collected. Because an incidence of precipitation in this context corresponds to a measure, for example in the form of snow ploughing, in other words there also ought to be a correlation between the amount of snow ploughing and the height above sea level. This was verified using the actual registrations made by the maintenance personnel, see figure 3. If this is also valid for other areas in the country, a method has been achieved to extrapolate data, together with a method to ensure the quality and to double check the registrations at the stations against what the personnel have noted has been carried out.

Figure 3 also shows the number of snow ploughing measures calculated from the index equation *(i)* plotted against the height above sea level. The figure indicates that the calculated number of snow ploughing (Test) has nearly the same height dependence as the number of actual executed measures (Ploughing).

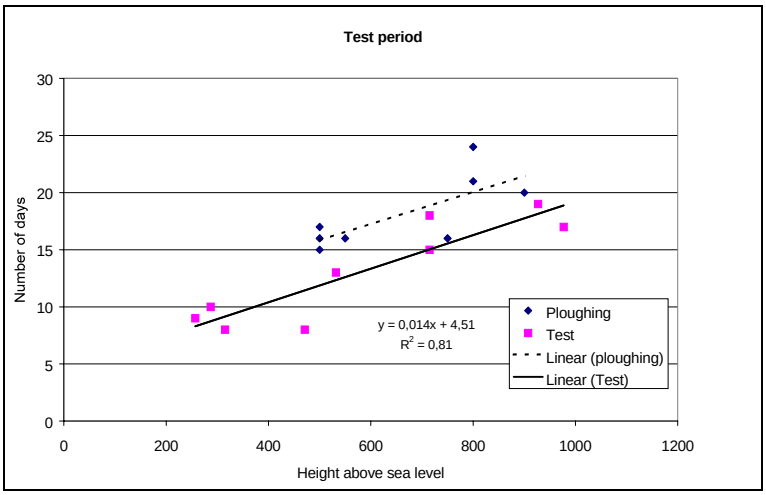

Figure 3: Number Of Days When Ploughing Has Been Carried Out, Plotted Against Height Above Sea Level

7. Sources of error

Possible sources of error for the winter index may be:

- Inadequate maintenance of stations and sensors.
  Inaccurate measurements, which result from inadequate maintenance, can lead to errors which may have serious consequences (for example amount of precipitation).
- Equipment and location of stations.
  The stations which provide data may be under-representative, too few in number or insufficiently equipped with sensors.
- Implementation of winter maintenance
  As a result of the limited response from maintenance personnel, there may be local variations in the way in which maintenance is carried out which have not been adequately described in the material which is used as a basis in developing the winter index.
- Inadequate weighting of parameters
  In areas with extraordinary weather and climate, it may be necessary to take certain parameters into consideration (e.g. drifting snow).

8. Further work

Since the network of stations is limited, it is necessary to find a method whereby the index, which is calculated from the data at one point, can apply to a larger area. In this context, it is important to chart the existing stations and the surrounding conditions so that there is sufficient knowledge of the type of climate (height above sea level, exposed mountain area, dense woodland etc) which the different stations are meant to represent.

Given that not all the registration points contain the same amount of data, it is also necessary to see how different sources may be combined to create a complete winter index. It is important to develop a method whereby data from road weather stations can be combined with data from DNMI. The project seeks to answers questions such as whether a parameter such as wind from one station, for example, can be combined with the road surface temperature and the air temperature from another station.

There are still a number of questions which need to be answered before a winter index will be suitable for use over the whole of Norway. Due to climatic conditions, only part of the road network is salted in Norway during the winter. The project must evaluate whether the winter index which is being developed today is adequate for all areas, independently of whether they are salted or not. It may be necessary to work with two different winter indices, depending on the type of winter maintenance

which is carried out on a particular stretch of road. In order to find answers to these questions, it is important to gain experience in using the winter index.

In 2001 the project will focus on the use of NORIKS and the requirements which users have for a winter index and the way in which it is presented. The winter of 2001 - 2002 will provide further answers as to whether the work which has been done is suitable for winter maintenance in Norway. A mathematical program will be developed with a web interface to make it easily accessible for users, and further registrations of winter maintenance measures will be carried out, in order to verify whether the winter index satisfies these requirements.

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